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# NAVAL POSTGRADUATE SCHOOL

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A SUMMARY OF THE  
FOUNDATION RESEARCH PROGRAM

March 1978

Report for the Period  
1 July 1976 to 30 September 1977

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Prepared for:  
Chief of Naval Research  
Arlington, Virginia 22217 and  
Chief of Naval Development  
Washington, D. C. 20360

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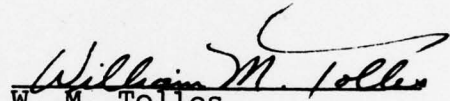
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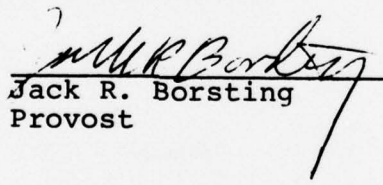
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Thirty-eight summaries of Independent Research/Independent Exploratory Development work carried out under funding to the Naval Postgraduate School Foundation Research Program. This research was carried out in the areas of Mathematics, Administrative Science, Operations Research, National Security Affairs, Physics & Chemistry, Electrical Engineering, Meteorology, Aeronautics, Oceanography, and Mechanical Engineering. A tabulation in the appendix I identifies area of research and the principal investigator. The category of independent research or independent exploratory research is also identified for each research task.		

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## FY 1977 FOUNDATION RESEARCH

### I. Introduction

The principal thrust of the research and exploratory development program at the Naval Postgraduate School (NPS) stems from its mission:

To conduct and direct advanced education of commissioned officers, and to provide such other technical and professional instruction as may be prescribed to meet the needs of the Naval Service; and in support of the foregoing to foster and encourage a program of research in order to sustain academic excellence.

In fulfillment of the research and development program objectives and within the above constraints, the Naval Postgraduate School

Initiates and conducts scientific and applied research (6.1) of a long-range nature in areas of special interest to the Navy.

Conducts exploratory development (6.2) deriving from scientific program areas or in other areas specifically requested by the Navy.

In addition, NPS performs scientific research and exploratory development, where uniquely qualified, for other agencies of the Department of Defense and, in defense related efforts, for other Federal Government agencies. NPS also furnishes consulting services for the Navy and, where specifically qualified, for other agencies of the Department of Defense and in defense related efforts for other Government agencies.

### II. Background on the NPS Research Program

The Navy has developed the Naval Postgraduate School as an academic institution which uses university educational methods to address the special graduate education requirements of the Navy. The Superintendent of the Naval Postgraduate School is a Rear Admiral of the line of the Navy. He is supported by a dual management structure, part military and part civilian. The faculty, mostly civilian, is responsible for the academic programs and, in support of these, conducts an active research effort. The military staff specifies the educational needs of the Navy, in terms of curricula, and provides administrative logistic support.

At the Naval Postgraduate School, as in other academic institutions, the faculty is organized into departments. The department represents a resource center of faculty members with allied disciplinary specialization. Currently, the departments at the Naval Postgraduate School include Computer Science, Mathematics, Administrative Science, Operations Research, Physics and Chemistry, Electrical Engineering, Meteorology, Aeronautics, Oceanography, Mechanical Engineering, and National Security Affairs. Inter-disciplinary groups which have effective departmental status include Acoustics, Anti-Submarine Warfare, Electronic Warfare and Command, Control and Communication (C3).

Research and development projects are largely conducted by the individual faculty members on a project basis. Projects typically originate from proposals prepared either by individual faculty members, or by groups of faculty members from the same or different departments.

The research program is divided administratively into two parts. First is the Sponsored Research Program. This program includes projects awarded by sponsoring agencies to an individual principal investigator. The principal source of funds is the various commands and laboratories of the Naval Material Command. The sponsored program constitutes about 80% of the total NPS research program. The Foundation Research Program is based on a grant from the Chief of Naval Research and the Chief of Naval Development. This program is administered internally by a Research Council. The Council meets periodically to review faculty proposals, allocate funding, and review results of completed projects.

Appendix I identifies each project by title and category or type funding (Research - 6.1 and Exploratory Development - 6.2). The 6.1 category was funded by the Chief of Naval Research, Arlington, Virginia 22217 and the 6.2 category was funded by Chief of Naval Development, Washington, DC 20360.

This report summarizes the FY 1977 Foundation Research Program.



Title: Computational Basis Functions For Optimal Approximations

Investigator: R. Franke, Associate Professor of Mathematics

Sponsor: Foundation Research Program (6.1)

Objective: The objective of the study was to investigate the feasibility of using the representers of point evaluation functionals as basis functions for the computation of optimal approximations. The main purpose, but not the only application, is to construct interpolation functions for data in two independent variables at scattered points. Other basis functions useful for computational purposes were to be developed.

Summary: The objective was to investigate the computation of optimal approximations in Sard corner spaces. Construction of basis functions suited for computation was proposed.

The use of the natural basis functions (representers of point evaluation functionals) was investigated by computing condition numbers of coefficient matrices for random sets of points. Two schemes for generating basis functions which are zero in certain regions were developed.

The use of the natural basis functions for computation of optimal approximations are possible in some cases. For large sets of data where smooth approximations are required, it is desirable to use local methods.

Publications: R. Franke, "On the Computation of Optimal Approximations in Sard Corner Spaces", to appear in SIAM J. on Numer. Anal.

R. Franke, "On the computation of Optimal Approximations in Sard Corner Spaces", Technical Report, NPS 53Fe76121, December 1976.

Title: Convergence of the Method of Parallel Displacements for Unconstrained Minimization in the Non-Quadratic Case

Investigator: I. B. Russak, Associate Professor of Mathematics

Sponsor: Foundation Research Program (6.1)

Objective: To establish the convergence characteristics of the method of parallel displacements (described below) in the non-quadratic case when using exact derivatives and numerical derivatives.

Summary: Problems in optimization occur very frequently in military applications, e.g., optimizing with respect to time to intercept the parameters of a missile interceptor system. Furthermore, since constrained optimization problems can often be stated in terms of unconstrained ones, then methods for solving the latter are very important. The method of parallel displacements is a powerful tool for solving unconstrained optimization problems and understanding its convergence characteristics is necessary for successful application to actual problems. In describing the method of parallel displacements we shall refer to the function  $f(X)$  where: i)  $f(X)$  is of class  $C^2$ , ii)  $X$  is an  $N$  dimensional vector, iii)  $f(X)$  is strictly convex.

The method of parallel displacements will now be described:

Starting with the  $N + 1$  initial points  $X_{1,1}, X_{1,2}, \dots, X_{1,N+1}$  which do not lie in an  $N-1$  dimensional plane, set  $P_1 = X_{1,N+1} - X_{1,N}$ . For  $j = 1, \dots, N$ , let  $X_{2j}$  be obtained as follows:

$$X_{2j} = X_{1j} + \alpha_{1j} P_1 \quad j = 1, \dots, N$$

where

$$\alpha_{1j} = \frac{-P_1^T f'(X_{1j})}{P_1^T f''(X_{11}) P_1}$$

with  $f'$ ,  $f''$ , " $T$ " denoting respectively, the first and second derivatives and the transpose. Set

$$P_2 = X_{2,N} - X_{2,N-1} \text{ and}$$

$$X_{3j} = X_{2j} + \alpha_{2j} P_2 \quad j = 1, \dots, N-1$$

where

$$\alpha_{2j} = \frac{-P_2^T f'(X_{2j})}{P_2^T f''(X_{11}) P_2}.$$

Continue this process in the same manner with

$$P_3 = X_{3,N-1} - X_{3,N-2} \text{ to get points } X_{4,j}$$

$$j = 1, \dots, N-2.$$

After  $N$  steps we obtain a point  $\bar{X} = X_{N+1,1}$ .

This completes one cycle of the method. The

point  $\bar{X}$  so obtained can be shown to provide a minimum of  $f$  if  $f$  is quadratic with a positive definite Hessian at its minimum point. If  $f$  is not quadratic, then we set  $X_{1,1} = \bar{X}$  and repeat the procedure.

Convergence of the method (i.e., of the sequence of points  $\{\bar{X}\}$  generated above) to a relative minimum of  $f$  has been established for the non-quadratic case when using exact derivatives and assuming a bounded third derivative for  $f$ . It remains to prove convergence when the assumptions on  $f$  are weakened and the exact derivatives are replaced by numerical derivatives. In addition the rates of convergence remain to be established.

Publications: None.

Title: Necessary Conditions for Problems Involving Higher Derivative Bounded State Variables

Investigator: I. B. Russak, Associate Professor, Mathematics

Sponsor: Foundation Research Program (6.1)

Objective: To develop necessary conditions for a minimum in the general control problem of Bolza with state inequality constraints in which the control enters in the second derivative of the constraint (described below).

Summary: A class of problems was investigated which includes the types found in a wide variety of applications such as in determining optimal ship routing and optimal missile trajectories. A particular example of the former is to find the route requiring minimum fuel for a ship which is required to reach a specified destination while satisfying conditions on propulsion limitations and also avoiding land masses. In this problem, propulsion is the control variable so that constraints on ship's position appear as state constraints (type iii in the problem definition) in which the control enters in the second derivative of the constraint.

The class of problems which has been investigated is described below:

Minimize the integral

$$i) \quad I_0(a) = g_0(b) + \int_{t_0}^{t^1} L_0(t, x(t), \dot{x}(t), u(t)) dt$$

in the class of trajectories

$$a: \quad x^i(t), \quad \dot{x}^i(t), \quad u^k(t), \quad b^\sigma$$

$$i = 1, \dots, N \quad k = 1, \dots, K \quad \sigma = 1, \dots, r \quad t^0 \leq t \leq t^1$$

which satisfy:

$$ii) \quad \ddot{x}^i = f^i(t, x(t), \dot{x}(t), u(t)) \quad i = 1, \dots, N$$

$$iii) \quad \psi^\alpha(t, x(t)) \leq 0 \quad \alpha = 1, \dots, m' \quad \psi^\alpha(t, x(t)) = 0 \\ \alpha = m' + 1, \dots, m$$

$$iv) \quad \theta^\eta(t, x(t), \dot{x}(t), u(t)) \leq 0 \quad \eta = 1, \dots, L' \\ \theta^\eta(t, x(t), \dot{x}(t), u(t)) = 0 \quad \eta = L' + 1, \dots, L$$



$$\text{v)} \quad I_{\gamma}(a) \leq 0 \quad \gamma = 1, \dots, p' \quad I_{\gamma}(a) = 0 \\ \gamma = p' + 1, \dots, p$$

$$\text{vi)} \quad x^i(t^s) = x^{is}(b) \quad \dot{x}^i(t^s) = \dot{x}^{is}(b) \quad i=1, \dots, N \\ t^s = T^s(b) \quad s = 0, 1$$

where

$$I_{\gamma}(a) = g_{\gamma}(b) + \int_{t^0}^{t^1} L_{\gamma}(t, x(t), \dot{x}(t), u(t)) dt \\ \gamma = 1, \dots, p$$

Necessary conditions are obtained for a solution to the above class of problems. Important features of this work are in : i) relaxing the solvability assumption on the state constraints while still permitting the solution trajectory to have an infinite number of intervals on the boundary, ii) extending the maximum principle to a larger set than previously realized, iii) developing modified forms of the relation  $\hat{H} = H_t$  and of the transversality relation usually obtained in problems of this type and iv) proving a condition concerning  $\dot{u}(t^1)$ , the derivative of the multiplier functions at the final point.

Publications: None.

Title                    Analysis of Methods For Estimating Reliability Bounds

Investigator:    A. L. Schoenstadt, Associate Professor of Mathematics.

Sponsor:            Foundation Research Program (6.1)

Objective:        The study investigated the accuracy of bounds on the reliability of a system, composed of a serial arrangement of independent, exponential failure law components, produced by two well-known, but different methods - the Lieberman-Ross Method and the Mann-Grubbs Method. The methods differ primarily in that the Lieberman-Ross method is a statistically exact procedure, whose bounds depend on the order in which failure data is recorded, while the Mann-Grubbs method is an approximately optimum procedure, whose bounds do not depend on data order. This is a continuing project.

Summary:          Both analytic and simulation methods were used to compare the estimated bounds produced by both methods, using identical data. In each instance, whichever method produced the lower upper bound on the hazard rate, without producing a false bound, was judged superior. It was shown that the Mann-Grubbs method generally produced superior bounds, except when very restrictive assumptions were made on the order in which failures were recorded, or on the size of the sample in relation to the relative component hazard rates.

Publications:    A. L. Schoenstadt, "A Comparison of the Lieberman-Ross and Mann-Grubbs Methods," Technical Report, NPS 53ZH76091, September 1976.

Title: The Calculation of  $e^{At}$  With Some Applications

Investigator: E. Stewart, Professor of Mathematics

Sponsor: Foundation Research Program (6.1)

Objective: The aim of this research was to obtain simple techniques for calculating  $e^{At}$  where  $A$  is an  $n \times n$  - matrix. The results of this work were to give these techniques in differential equations courses where  $e^{At}$  becomes a natural part of a solution to a system of simultaneous linear, first order differential equations.

Summary: After obtaining the eigenvalues of a matrix  $A(n \times n)$ ,  $e^{At}$  is then obtained as the solution of an initial value problem for an  $n$ th order differential equation with constant coefficients. In the process of obtaining the unique solution under the given initial conditions,  $n$  matrices must be determined. These matrices turn out to be pairwise orthogonal and idempotent or nilpotent and these properties characterize the matrices. Using these properties formulae are obtained for calculating  $e^{At}$ . The three possible cases are:

- a)  $A$  has simple eigenvalues.
- b)  $A$  has one eigenvalue of multiplicity  $n$ .
- c)  $A$  has various eigenvalues of multiplicities one or more.

Applications are then given for obtaining solutions to various linear systems of differential equations.

Publications: None

Title: Derivation of Critical Planning Properties of The Process Associated With Generating Demands For Health Care

Investigator: D. Whipple, Associate Professor of Administrative Sciences

Sponsor: Foundation Research Program (6.2)

Objectives: To develop analytically the major parameters involved in the generation of demands for health care resources given the significant agency relationship of the physician for the patient. These will be used to analyse the budgetary process used in the Military Health Services System (MHSS) under its present structure and to recommend changes where applicable.

Summary: An economic mathematical programming optimization model previously developed by the investigator will be modified and extended to develop testable hypotheses concerning the probable outcome of various parametric changes in the structure of the MHSS in terms of cost by the physician-agent and the patient. These outcomes will be analysed in light of present or suggested organizational change initiatives in the MHSS, and recommendations for empirical policy research made.

Conference Presentations: D. Whipple, "Development of Management Incentives to Accompany Capitation Budgeting in U. S. Military Health Care Delivery System", presented at the 10th Annual Health Systems Research Symposium in Miami, November 1-2, 1976, also chaired a session.

D. Whipple, "The Contribution of Non-Physician Providers to the Search for a More Equitable and Efficient Health Care Delivery System", presented at the American Association for the Advancement of Sciences, San Francisco, June 12-15, 1977, also chaired session.



D. Whipple, "Structural Change in the U. S. Military Health Care Delivery System: Goal of Cost Containment", presented at the North American-European Comparative Health Systems Evaluation Congerence, Milan, Italy, September 11-15, 1977.

Publications: None

Title: Investigation of a Sequential Median Test

Investigator: D. R. Barr, Professor of Operation Research

Sponsor: Foundation Research Program (6.2)

Objective: To assess properties of a sequential test based on sample medians, including expected sample size and operating characteristics.

Summary: Empirical evidence was obtained through simulation which demonstrates potential usefulness of the proposed test. This evidence suggested the sample number has asymptotic geometric distribution; efforts were undertaken to demonstrate this analytically, but to date have not been successful.

Publications: None.

Title: Analysis of a Class of Binary Trees Arising From Certain Applications in Sorting and Information Retrieval

Investigators: G. G. Brown, Associate Professor of Computer Science and Operations Research

B. O. Shubert, Associate Professor of Operations Research

Sponsor: Foundation Research Program (6.1)

Objective: Combinatorial examination of a class of Binary Trees with the view of providing information useful in analysis of algorithms based on this widely used storage structure.

Summary: Exact and asymptotic results are given for equally likely trees and those grown by binary insertion tree sorts applied to random strings of key symbols. Tabulations are now available on the results. Two observations are noteworthy. First, the universally held belief that randomly grown trees will become misshapen and require frequent pruning or reorganization to avoid excessive access path lengths in subsequent use is false. Second, the degree to which randomly grown trees depart from balanced symmetric structure provides an excellent new nonparametric hypothesis test for randomness of sequences.

Publications: G. G. Brown and B. O. Shubert, "On Random Binary Tree," Technical Report NPS55Bw76061, (July 1976).

Title: Lanchester-Type Models of Warfare (Monograph)

Investigator: J. G. Taylor, Associate Professor of Operations Research

Sponsor: Foundation Research Program (6.1)

Objective: To continue writing a monograph on Lanchester-type (i.e. differential-equation) models of warfare. The monograph will be a state-of-the-art summary as well as an introduction to analytical models of combat attrition and will attempt to integrate and synthesize widely scattered results and modelling ideas.

Summary: The writing of the monograph was continued, with the outline of the book undergoing major revision. Substantial portions of the first three chapters were written, and the first chapter on background and introduction (i.e. the general nature of combat models) was revised. The initial portions of the book have been largely tutorial in nature, and consequently numerous examples have been given to illustrate many points about various basic Lanchester-type models. Additionally, some previously pending related research (to ultimately be incorporated into the monograph) was completed, and also an invited address entitled "State-of-the-Art Summary of Lanchester Theory" was delivered at the 15th Army Operations Research Symposium.

Conference Presentations: J. G. Taylor, "Concentration of Forces in Some Lanchester-Type Combat Models," presented at the Western Section of ORSA 1976 Meeting, Los Angeles, CA, 16-17 September 1976.

J. G. Taylor, "State-of-the-Art Summary (Lanchester Theory)," presented at the Annual U.S. Army Operations Research Symposium, Fort Lee, VA, 27-29 October 1976. (invited by program committee).



J. G. Taylor and G. G. Brown, "Further Canonical Methods in the Solution of Variable-Coefficient Lanchester-Type Equations of Modern Warfare: A New Definition of Power Lanchester Functions", presented by J. G. Taylor at the Miami Joint ORSA/TIMS National Meeting, Miami Beach, FL, 3-5 November 1976. Abstract in ORSA Bulletin.

Publications:

J. G. Taylor and G. Comstock, "Force-Anihilation Conditions for Variable-Coefficient Lanchester-Type Equations of Modern Warfare", Naval Research Logistics Quarterly 24, 349-371 (1977).

J. G. Taylor, "Predicting Battle Outcome with Liouville's Normal Form for Lanchester-Type Equations of Modern Warfare", Opsearch 14, 185-203 (1977).

J. G. Taylor, "Optimal Commitment of Forces in Some Lanchester-Type Combat Models", Technical Report, NPS55-77-2, January 1977.

J. G. Taylor and G. G. Brown, "Numerical Determination of the Parity-Condition Parameter for Lanchester-Type Equations of Modern Warfare", Technical report, NPS55-77-10, March 1977.

J. G. Taylor, "Error Bounds for the Liouville-Green Approximation to Initial-Value Problems", Technical report, NPS55-77-29, June 1977.

Theses Directed: Herbert H. Mauerer (Captain, West German Army), "Design Considerations for Lanchester-Type Models of Warfare (LATMW)", Master's Thesis September 1976.

Title: Convexity in an Inventory Model

Investigator: P. W. Zehna, Professor of Operations Research

Sponsor: Foundation Research Program (6.2)

Objective: The Hadley-Whitin Q-r models in inventory theory have been widely used by practioners for some time now in spite of questions regarding their validity. The purpose of this research was to extend the author's investigations in these matters to hopefully characterize the proper solutions.

Summary: Beginning with some recently completed research in the backorders case, the author was able to successfully complete the research and give a full characterization of the solutions. Continuing with the lost sale case, one that had not been previously studied, the investigator was able to show that, while the situation was not as bad in this case, a similar anomaly existed and again, it was possible to completely characterize the solution in this new case also.

Publications: P. W. Zehna, "Solutions in Hadley-Whitin Q-r Models" submitted to the Naval Logistics Quarterly.

Lenna, Peter W., "Solutions in Hadley-Whitin Q-r Models:", Naval Postgraduate School Technical Report NPS 55-78-4, January, 1978.

Title: Canadian Armed Forces Unification: The Effects After Ten Years

Investigator: D. P. Burke, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To update, through research in Canada, a previous study by the principal investigator on the unification of the Canadian Armed Forces.

Summary: Ten years have passed since the abolition of the Canadian Army, Navy and Air Force and the creation of a single service in their place. Most of the dire effects on morale and efficiency which were predicted by opponents of the step have not occurred. Severe budgetary stringency (which was relieved somewhat by unification) has had a much more serious effect, and preference in promotion and assignment given to French Canadians is of much more immediate concern, at least to English speakers. However, the expectations of the authors of unification have also been partly disappointed. With the 1976 creation of Air Command, institutions which parallel each of the old services now exist in the new, and the terms "army", "navy" and "air force" are again in daily use. Significant savings in overhead have been made, but flexibility in personnel policy is seriously hampered by the persistence of regimental and corps organization in the new Service. There is no serious sentiment in the Forces or the Government for a return to a three-service organization.

Publication: None

Title: The Use of Expert Opinion in Congressional Roll Call Analysis

Investigator: E. J. Laurance, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To experiment with quantified judgment techniques in assessing Congressional behavior.

Summary: One of the methods commonly used to assess Congressional behavior regarding defense policy is the construction of scales based on roll call votes on defense issues. Typically, these are constructed using Guttman scaling or factor analysis, both of which assume that all votes in the scale are of equal importance. This research involved experimenting with several types of weighting techniques which relied on the judgments of experts knowledgeable of the defense issues involved. Techniques such as paired comparison and constant sum were used to construct weighted scales and compared with scales constructed in a purely statistical manner.

Publications: None



Title: The CENTO Alliance: Status and Prospects

Investigator: R. H. Magnus, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To determine the current status of the alliance among its member and associated states. What should be the policy of the United States towards it?

Summary: Although there are differences in the perceptions of the member and associated states, there still remains a common core of agreement on the utility of the alliance centered around a shared antagonism towards Soviet activities in the area. Regional members would, in general, like to see the alliance take a more active role in regional issues. The United States has consistently resisted these pressures. In view of the increasing importance of the resources of the Persian Gulf for the United States, it is recommended that the alliance should be, at least, maintained and, quite possibly, strengthened.

Publications: None

Title: The USSR, Eastern Europe and Eurocommunism

Investigator: J. Valenta, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To write a paper on Soviet and East European perceptions of and responses to Eurocommunism in Western Europe.

Summary: The research of this paper was conducted and concluded. The paper drew extensively on Soviet and European sources. After the paper was completed an invited address entitled "Eurocommunism in Eastern Europe" was delivered at the 1977 Annual Convention of the American Association for the Advancement of Slavic Studies, Washington, DC.

Publications: J. Valenta, "The Impact of Eurocommunism on Eastern Europe," Problems of Communism, March-April 1978 (forthcoming).

J. Valenta, "The USSR and Eurocommunism," The USSR and Eastern Europe, T. Rakowska and A. Gyorgy (eds.) (Indiana University Press, forthcoming, 1979.)

Title: The Soviet Intervention in Czechoslovakia, 1968

Investigator: J. Valenta, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To finish writing a revised manuscript on the Soviet intervention in Czechoslovakia in 1968. The manuscript will be a comprehensive study analyzing the Soviet management of the Czechoslovak crisis of 1968. It will also be a test of the bureaucratic politics paradigm as a methodological tool to be used in explaining Soviet foreign policy behavior.

Summary: The first chapter on the bureaucratic politics model was revised and substantial portions of the following three chapters were rewritten. The monograph was completed and sent to the publisher. Also, an invited address entitled "Bureaucratic Politics and Soviet Foreign Policy" was delivered at the Annual Convention of the American Association for the Advancement of Slavic Studies, Washington, DC, October, 1977.

Publications: J. Valenta, Anatomy of a Decision: Soviet Intervention in Czechoslovakia, 1968, manuscript in which Johns Hopkins University Press has expressed great interest and is now considering for publication.

J. Valenta, "Soviet Intervention in Czechoslovakia," in Ivan Volgyes (ed.), Czechoslovak Political Tradition (Festschrift for Professor J. Korbél), Columbia University Press, forthcoming, 1978.

Title: The Soviet-Cuban Intervention in Angola

Investigator: J. Valenta, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To continue writing a monograph on the Soviet and Cuban intervention in Angola in 1975. The monograph will be an analytical research summary of the external and internal factors which influenced the Soviet-Cuban management of the Angolan crisis of 1975. It will likewise be a useful introduction to further research testing the formation of a probable pattern for the prediction of future Soviet and Cuban military involvement in Africa.

Summary: The writing of the monograph, which draws extensively on Soviet, Cuban and African sources, has been compiled and substantial portions of the manuscript will be published. Furthermore, some previously pending related research was completed.

Publications: J. Valenta, "The Soviet-Cuban Intervention, 1975," in David Albright (ed.) The Great Powers in Africa (Westview Press, forthcoming, 1978).

J. Valenta, "The Angolan Intervention, 1975," Studies in Comparative Communism, forthcoming, winter 1979 (The editor-in-chief of the journal requested the paper which is now being considered for publication.)



Title: Investigation of Nuclei Giant Multipole Resonances  
by Inelastic Electron Scattering

Investigators: F. R. Buskirk, Professor of Physics  
J. N. Dyer, Professor of Physics  
R. Pitthan, Assistant Professor of Physics

Sponsor: Foundation Research Program (6.1) and National  
Science Foundation Grant

Objective: The inelastic electron scattering experiments  
with  $^{58}\text{Ni}$ ,  $^{60}\text{Ni}$  and  $^{238}\text{U}$  were undertaken with  
excitation energies up to 40 MeV. The present  
measurements combined with earlier work on  $^{208}\text{Fb}$ ,  
 $^{197}\text{Au}$ ,  $^{165}\text{Ho}$  and  $^{89}\text{Y}$  form part of a survey of  
the systematics of the giant resonances in medium  
and heavy nuclei.

Summary: The Nickel experiments ( $^{58}\text{Ni}$  and  $^{60}\text{Ni}$ ) were  
performed at 102 MeV and scattering angles of  
45, 60, 75 and 90 degrees. One striking result  
concerns the giant dipole resonance, which in  
( $\gamma, n$ ) experiments is much smaller for  $^{58}\text{Ni}$  com-  
pared to  $^{60}\text{Ni}$ . Our experiments, which measure  
the total E1 strength, not just the ( $\gamma, n$ ) chan-  
nel, show precisely the opposite result, namely  
that  $^{58}\text{Ni}$  has the larger E1 strength. If ( $e, e'$ )  
and ( $\gamma, n$ ) results are to be reconciled, either  
the ( $\gamma, p$ ) experiments are wrong or some other  
channel, possibly ( $\gamma, D$ ) must be present and large  
in  $^{58}\text{Ni}$ , but small in  $^{60}\text{Ni}$ .

The Uranium experiments, 87.5 MeV at angles of  
45, 60, 75 and 90 degrees were undertaken to extend  
our survey to an extremely heavy nucleus, which is  
not only deformed, as is  $^{165}\text{Ho}$ , but fissionable.  
The established resonances were seen including  
the split dipole resonance. Unexpected results  
for both the isoscalar and isovector quadrupole  
modes were the small strengths corresponding to  
about half the sum rule in both cases. Also these  
states were not as broad as one would expect for  
a deformed nucleus.

The resonance highest in energy, at 28.4 MeV or  
 $176 A^{-1/3}$  MeV, fits an E3 angular distribution  
and corresponds to 90% of the sum rule. Possibly  
this state corresponds to the ones seen in  $^{197}\text{Au}$ ,

$^{208}\text{Pb}$  and  $^{165}\text{Ho}$ , which were not identified at the time. If these are the same state, it may be noted that the energy expressed in  $A^{-1/3}$  units shifts from  $175 A^{-1/3}$  for the deformed fissionable to  $195 A^{-1/3}$  MeV for spherical nuclei.

- Publications: R. Pitthan, R. R. Buskirk, E. B. Daley, J. O. Shannon and W. H. Smith, "Giant Resonances and Bound Collective States Observed in the Scattering of 92.5 MeV Electrons from the Closed-Neutron-Shell Nucleus  $^{89}\text{Y}$  Between Excitation Energies from 2.0 to 55 MeV", Physical Review C **16**, 970 (1977).
- R. Pitthan and F. R. Buskirk, "Isospin of the Fine Structure Between 8 and 12 MeV in  $^{208}\text{Pb}$  and its Implication for the Multipole Assignment of the 8.9 MeV Resonance", Physical Review C **16**, 983 (1977).
- R. Pitthan, J. S. Beachy, F. R. Buskirk and S. J. Kowalick, "Resonant Octupole Strength at 13 MeV in  $^{58}\text{Ni}$  and  $^{60}\text{Ni}$  and the Character of the  $53 A^{-1/3}$  State in Heavy Nuclei", (submitted).
- J. S. Beachy, S. J. Kowalick, F. R. Buskirk and R. Pitthan, "Difference in  $E_1$  Strength of  $^{58}\text{Ni}$  ( $T=1$ ) and  $^{60}\text{Ni}$  ( $T=2$ ) at Deuteron Threshold", (submitted).
- W. A. Houk, R. W. Moore, F. R. Buskirk and R. Pitthan, "Evidence for an Isovector Octupole Resonance at 28.4 MeV and Other Giant Resonances in  $^{238}\text{U}$ ", (submitted).

Title: Laser Produced Plasmas

Investigators: A. W. Cooper, Professor Physics  
F. Schwirzke, Associate Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: In the continuing project, the interaction is investigated between intense laser pulses and targets. The dynamics of the laser produced plasma and self-generated magnetic fields are studied.

Summary: Experimental evidence has been found that magnetic fields are generated in the steepened front of a fast moving plasma plume which is interacting with a background plasma. A laser produced plasma expands in z-direction normal to the target surface with a velocity of about  $10^7$  cm/sec. If the laser produced plasma flows into a photo-ionized background plasma of sufficient density, shock heating at the front will produce a temperature gradient in z-direction. Magnetic fields in azimuthal direction are then generated long after laser shutoff by the cross product of the radial density gradient and the electron temperature gradient in z-direction. The location of the peak magnetic field coincides with the steepest gradient in the shock front. Very basically, spontaneous magnetic fields should be generated whenever a shock is produced by a plasma streamer.

Conference Presentations: F. Schwirzke, "Spontaneous Magnetic Fields in Laser-Impact Craters", presented at the Eighteenth Annual Meeting of the Division of Plasma, American Physical Society, 15-19 November 1976, San Francisco, CA. (abstract published in Bulletin American Physical Society 21, 1029 (1976), paper co-authored with A. W. Cooper).

F. Schwirzke, "Spontaneous Magnetic Field Generation in Shock Waves", presented at the Nineteenth Annual Meeting of the Division of Plasma Physics of the American Physical Society, 7-11 November 1977, Atlanta Georgia (Abstract published in Bulletin of the American Physical Society, 22 1160 (1977), co-authored with A. W. Cooper.



Title: Computer Simulation of Sputtering by Molecules

Investigator: D. E. Harrison, Jr., Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: To examine the containment and interaction of collision cascades when the sputtering of a copper crystal by a diatomic ion is simulated in the computer.

Summary: Most of the time was devoted to the development of a new generation of the computer program which has been the basis of this line of research. The computer results have now been interpreted to indicate that the interaction of collision cascades is much more prevalent and important than previously assumed. The research will continue.

Publications: None

Title: Magnetic Noise in and near The Ocean

Investigator: O. Heinz, Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: The objective is to obtain improved long term data on the magnetic noise on the ocean floor, within the ocean and immediately above the surface. By using a combination of total field magnetometers and VLF receivers it is planned to cover the frequency range from mHz to KHz.

Summary: Using a Cs vapor optically pumped magnetometer, we are currently measuring the spectrum of the geomagnetic field fluctuations in two frequency bands: 0.1 Hz to 25 Hz and 1 Hz to 256 Hz. This work is being done at our field site at La Mesa Village in Monterey. At the same time measurements were initiated from the Research Vessel Acania using a self contained VLF Receiver and tape recorder which was lowered into Monterey Bay. Measurements were taken at 50 feet intervals (during descent and ascent) and the instrument package was placed on the ocean floor at a depth of 300 feet for about 15 minutes. Since both of these measurements are still in their initial phases no results are available at this time.

Publications: None.

Title: Spectroscopic Data Center: Compilation of Short Ultraviolet (XUV) Spectra

Investigator: R. L. Kelly, Professor of Physics

Sponsor: Foundation Research Program (6.1), and National Aeronautics and Space Administration

Objective: It is planned to maintain, on a continuing long-term basis, a complete and critical compilation of atomic and ionic spectrum lines with wavelengths below 2000 Angstroms, for the first 36 elements.

Summary: The published literature is searched and relevant publications obtained. The observed spectrum lines are compared on a line-by-line basis, with those predicted from the known atomic energy levels (a complete file of energy levels is maintained). Those lines satisfying established criteria are retained in the files. The published intensities are normalized, and multiplet numbers are added. Approximately 70,000 lines are presently stored in the files.

Publications: None

Title: Elastic Waves in Crystals

Investigator: J. R. Neighbours, Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: The objectives of this research are two-fold. First, to formulate a vector relation similar to the Poynting vector in electromagnetism for describing the flow of elastic energy in an anisotropic crystal. Second, to investigate the reflection of an elastic wave at the boundary between two anisotropic media.

Summary: Elasticity is a fourth rank tensor, a relation between two second order tensors. However, as a result of various symmetries, the elastic constants are describable by a symmetric 6 x 6 array rather than by 81 components. Thus they can be represented as a matrix and transformed accordingly.

Propagation of elastic waves is similar to optical birefringence except that elastic waves can also have longitudinal polarization and might properly be called a case of trirefringence.

Progress on this project has been to carefully formulate the matrix transformation in coordinates rotated with respect to the primary stress reference axes, and to find the solutions to the eigenvalue problem in the rotated coordinates. A computer program in BASIC has been written for this purpose. From the eigenvalues, both wave velocity and wave slowness (similar to an index of refraction surface) surfaces have been constructed. So far these calculations have been confined to cubic, hexagonal and orthorhombic crystals. Many real crystals have been investigated and the special pure mode directions have been tabulated.

A related problem is the sensitivity of the elastic constants to inversion. The elastic



constants are the coefficients when the stresses are expressed as linear functions of the strains. An alternative formulation is of the strains in terms of the stresses. The product of the two matrices is the unit matrix, and different types of experiments measure components of one or the other of the matrices. In order to compare different types of measurements, it is desirable to know how the elements of one matrix vary with respect to variation of a single element of the other. A program has been written for this purpose and many real crystals have been investigated.

This project is now being actively carried out on an extracurricular basis.

Publications: None

Title: Homogeneous Catalysis by Palladium Complexes

Investigator: R. A. Reinhardt, Professor of Chemistry

Sponsor: Foundation Research Program (6.1)

Objective: Determination of rate laws for the oxidation of the olefin trans-2-butene by several palladium (II) complexes. This research was initiated in late 1975 and continued to the end of calendar year 1976.

Summary: The experiments were conducted by use of gas chromatography to analyze for both reactant olefin and product ketone. Early results using  $\text{PdCl}_4^{2-}$  as oxidant, gave results in accord with published data on the system obtained by a totally different technique. Preliminary results on the  $\text{PdBr}_4^{2-}$  - olefin system, though showing internal inconsistencies, showed promise of ultimately yielding reliable results and these formed the basis of a paper presented before the Northwest Regional Meeting of the American Chemical Society in Reno, Nevada, June 1976.

Continued studies, however, were unable to improve the discrepancies. In particular, the analyses for reactant and product could not be reconciled with material balance in the system. In addition, data of a given run would show wide scatter, and, in many cases, replicate runs gave differences in computed rate parameters far outside any tolerable error.

It can be surmised that the difficulties are inherent in the experimental method, which is thus inappropriate for the system. A real possibility is loss through vaporization of the extremely volatile substrate olefin at varying rates during the course of a run. It is not proposed to continue the investigation.

Publications: None.

Title: Frequency Response of Cold Wires Used for Atmospheric Turbulence Measurements in the Marine Environment

Investigators: G. A. Schacher, Associate Professor of Physics  
G. W. Fairall, Assistant Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: The purpose of this project is to determine the effect of sea salt deposition on the frequency response of platinum wires used for measuring thermal turbulence. These wires are operated at ambient temperature, are very small ( $\sim 2 \mu$  diameter), and their small time constant allows them to follow temperature changes as rapid as several kilohertz. When they are operated in the marine environment spray and aerosols deposit sea salt on the wires. This salt can form a film which could alter the wires' frequency response.

Summary: We have developed methods for coating the wires and measuring their frequency response in controlled conditions in the laboratory. The salt is deposited by spraying a fine mist of salty water over the wires and allowing the droplets to evaporate on the wires. This is accomplished in a large chamber 4ft high by 1½ft diameter. The salted wire is tested in an airstream which contains a "white" spectrum of temperature fluctuations, and its response is determined with a spectrum analyzer.

Development of the system to create the white temperature spectrum has been completed and the salted temperature wires have been tested. the results show that the frequency response of the wires can be significantly affected as low as 10 Hz, but only with amounts of salt that are far in excess (about 100 x) of that normally encountered in experiments at sea. The experimental portion of the work has been completed and comparison with theory is underway.

Publications: None

Title: Interval Modulation of a Sinusoidal Carrier

Investigator: G. Myers, Associate Professor of Electrical Engineering

Sponsor: Foundation Research Program (6.2)

Objective: This work is concerned with radio communications. This research investigated use of a modulated interval, between bursts of a sinusoidal carrier, to convey the information in a message waveform. We called this form of modulation "interval modulation" (IM).

Summary: IM produces a delay between bursts of the sinusoidal carrier. This delay is proportional to the amplitude of the modulating message waveform. Thus, IM is unlike AM, PM, or FM where the amplitude, frequency or phase of a sine wave vary in accordance with a message waveform.

The research resulted in mathematical descriptions of the IM carrier in the time domain and frequency domain. Early in the investigation, we completed the design of an IM modulator and demodulator. We then built and tested these circuits. The technique was then verified by transmitting voice and music signals through the system. The quality of the recovered signals was excellent.

Conference Presentations: G. Myers, "Interval Modulation (IM) of a Sinusoidal Carrier", Technical Conference, SIEEM 77, Monterey, Mexico, September 77.

G. Myers, "Symposium on Spread Spectrum Communications", Naval Postgraduate School, September 1976.



Publications: G. Myers and E. L. Kilborn, Jr., "Interval Modulation (IM) of a Sinusoidal Carrier", Technical Report, NPS62Mv77031, February 1977.

Thesis Directed: E. L. Kilborn, Jr., "Interval Modulation (IM) of a Sinusoidal Carrier", Master's Thesis, December 1976.

Title: Researches in Digital Filters

Investigator: S. R. Parker, Professor of Electrical Engineering

Sponsor: Foundation Research Program (6.1)

Objective: To extend previous work on one dimensional filters to the multidimensional case in the general areas of synthesis, stability, and limit cycles.

Summary: A direct technique for expressing the impulse response of a multidimensional digital filter in terms of the coefficients of the transfer function is presented. This approach potentially leads to a synthesis procedure for recursive two dimensional signal processing.

An adaptive recursive digital filter has been developed and compared favorably with the optimal filter. The feedforward and feedback gains of the filter are adjusted adaptively to minimize a least square performance function on a sliding window average basis for gradient calculations.

Publications: S. R. Parker, L. Souchon, "Synthesis of N Dimensional Recursive Digital Filters by Taylor Series Expansion", IEEE Transactions on Circuits and Systems, Vol CAS24, No. 1, January 1977, pp 28-34.

Title: Computer Aided Acoustical Imaging

Investigator: J. P. Powers, Professor of Electrical Engineering

Sponsor: Foundation Research Program (6.2)

Objective: This work is part of a continuing effort to explore the use of computer processing of coherent (both amplitude and phase information present) data to generate images of objects from transmitted or reflected ultrasonic fields. The short term objective was to construct an experimental system to record the complex data fields of an ultrasonic wave for computer processing. Additionally it was desired to explore the presentation of the data on a computer driven video display for presentation of the data or resulting image.

Summary: The first acoustic images using this system have been obtained. The data acquisition system has been built and successfully tested. Preliminary acoustical images have been displayed on a Ramtek Gx-100 television display with 16 gray levels (limited by the display refresh memory capability). The data acquisition system consists of a logarithmic compressive amplifier with 60db of dynamic range, a phase detector, and a high accuracy positioning and recording system. Testing and calibration of the hardware implementation of these devices shows acceptably high degrees of accuracy and repeatability. The data is recorded on analog tape. After digitization of the recorded data and subsequent demultiplexing of the channels the data has been successfully stored in memory of PDP 11/40 computer for subsequent display or processing. Using the Ramtek Gx-100 display driven by a PDP 11/40, interactive display capability has been developed to allow the operator to call up displays of amplitude, phase or intensity data. He also has the capability to change the quantization levels, the gray scale assignment and to assign various pseudocolor values to the data. This interactive capability was designed and tested during the research period using both computer generated and experimentally recorded data. Future efforts include further expansion of this

interactive display capability, refinements in the data acquisition system and investigation of more experimental objects to assess the overall capabilities of the system.

Publications: J. P. Powers, "Computer Simulation of Linear Acoustic Diffraction, Acoustical Holography," Vol. 7, L. W. Kessler, Ed., Plenum Press, New York, 1977, pp. 193-205.

J.P. Powers, Lt. R. T. O'Bryon, Lt. J. W. Patton, "Ultrasonic Imaging System Incorporating Computer Aided Coherent Processing", Abstracts, Ninety-fourth Meeting of the Acoustical Society of America, Miami Beach, 12-16 December 1977, in J. Acoustical Society of America, 62 (Supplement 1): S22, 1977.



Title: Sampled Analog Signal Processing

Investigator: T. F. Tao, Professor of Electrical Engineering

Sponsor: Foundation Research Program (6.2)

Objective: To develop theory, design procedure and applications of sampled analog recursive filters using charge transfer devices.

To investigate the limitations and sensitivities of sampled analog signal processing.

Summary: Signal processing can be generally separated into four categories:

Filter	Recursive
	Nonrecursive
Spectral	Fourier Type
Analyzers	Non-Fourier Type

They can be implemented either digitally using computers, integrated circuits or in sampled analog ways using charge transfer devices. Sampled analog signals differ from digital signals because their amplitudes are not digitized. They are similar because both types of signals are sampled. This study is concerned with two aspects of sampled analog signal processing.

(1) Sampled Analog Recursive Comb Filters:

Theory, design procedure and applications of sampled analog recursive filters have been investigated. It was found that recursive filters using sampled analog delay lines behave in many ways similar to the digital recursive filters but with one major difference. Because a charge transfer delay line usually has delay of multiple sampling periods, the frequency characteristics of a sampled analog recursive filter has  $N/2$  comb teeth below the Nyquist frequency. It is a comb filter. It was found that theories and design procedure

developed for digital recursive comb filters can be used for sampled analog recursive comb filters if two modifications are made: filter coefficients vary with frequency, charge transfer delay lines have delays of multiple sampling periods. Two types of comb filters have been studied: canceller type and integrator type. Their applications as MTI radar canceller and pulse-repetition-frequency sorter have been demonstrated.

(2) Sampled Analog Discrete Fourier Transforms:

Two algorithms have been used to implement sampled analog discrete Fourier transforms: Chirp Z Transform and Prime Transform. Both algorithms use the transversal filter which can be easily implemented using charge transfer devices. This study investigated the advantages and limitations of these two sampled analog discrete Fourier transforms in comparison with the digital FFT (fast-Fourier-transform) algorithm.

Publications:

S. Holmes, "Hardware Signal Processor Development-Session Summary", Proceedings 9th Asilomar Conference on Circuits, Systems, and Computers, pp. 289-299 (1976).

S. Holmes, M. Pollack and J. Campbell, "Sensitivity Study of Sampled Analog Signal Processing", Proceedings 19th IEEE Midwest Symposium on Circuits and Systems, pp. 430-439, (1976)

L. Saetre, S. Holmes and A. Ejaz, "Recursive CTD Comb Filter and Its Application to MTI Radar Signal Processing", Proceedings 1976 GOMAC Conference, (Government Microcircuit Applications Conference), pp. 246-249 (1976).

J. Campbell, T. F. Tao and M. Pollack, "Sensitivity Study of Chirp Z Transform and Prime Transform as Sampled Analog Discrete Fourier Transform Algorithms", Proceedings of 10th Asilomar Conference on Circuits, Systems and Computers, pp. 372-38- (1976)

T. F. Tao, S. Holmes A. Ejaz, F. Piazza, L. Saetre and B. Freund, "Theory and Applications of Sampled Analog Recursive CTD Comb Filters", Proceedings NASA/JPL Conference on Charge Coupled Device Technology and Applications, pp. 1-10, (1976)

Theses Directed: J. Campbell, "Sensitivity Study of the Chirp Z Transform and the Prime Transform as Sampled Analog DFT Algorithms", Master's Thesis, December 1976

A. Ejaz, "Theory of Sampled Analog Recursive Comb Filters and Their Cancellation Applications", Engineer Degree, December, 1976.

F. Piazza, "Theory and Applications of CTD Recursive Comb Filters", Master's Thesis, December 1976.

Sklivanos, "Sensitivity Study of Sampled Analog Tapped Delay Line Transversal Filters," Master's Thesis, September 1976.

Title: Aerodynamic Stabilization of Gaseous Discharges

Investigator: Oscar Biblarz, Associate Professor of Aeronautics

Sponsor: Foundation Research Program (6.2)

Objective: The main objective is to define practical aerodynamic means for stabilizing discharges for electrical laser. Other applications in cold plasma chemistry are also envisaged. A particular objective was to become acquainted with supersonic flow and vortex flows as stabilizing agents and, furthermore, to examine the theoretical aspects of aerodynamic stabilization. This is one part of a continuing project.

Summary: The work undertaken complements the activities in turbulence stabilization which have been underway at the Naval Postgraduate School. First-hand experience with supersonic flow and vortex-flow equipment was obtained. The problem of analyzing the effects of turbulence in a discharge was given some perspective, and the classical or Schottky solution for the positive column in a flow discharge was re-examined in the light of the stability problem. The program will continue with more studies with turbulence.

Conference Presentations: O. Biblarz, E. Wassertrom and Y. Crispin, "Stabilization of Flow Discharges by Supersonic Flows", presentation at the 30th Annual Gaseous Electronics Conference, 18-21 Oct. 1977, Palo Alto, CA, (abstract in conference record and in bulletin of the American Physical Society.

Publications: O. Biblarz, J. L. Barto, and H. A. Post, "Gas Dynamic Effects on Diffuse Electrical Discharges in Air", Israel Journal of Technology, Vol. 15, No. 1-2.

O. Biblarz, J. L. Barto, and H. A. Post, "Gas Dynamic Effects of Diffuse Electrical Discharges in Air", 19th Israel Annual Conference on Aviation and Astronautics, Tel Aviv-Haifa, March 2-3, 1977, (full paper on



conference record).

Y. Khait and O. Biblarz, "Influence of Turbulence on diffuse Electrical Gas Discharges Under Moderate Pressures". Paper submitted to the Journal of Applied Physics .

O. Biblarz, "Aerodynamic Stabilization of Gaseous Discharges", Technical Report, NPS-67Bi771111, 1 November 1977.

Title: Acoustic Variability and Air-Sea Exchange

Investigators: W. W. Denner, Associate Professor of Oceanography  
K. L. Davidson, Associate Professor of Meteorology  
T. M. Houlihan, Associate Professor of Mechanical Engineering  
J. V. Sanders, Associate Professor of Physics  
E. B. Thornton, Associate Professor of Oceanography

Sponsor: Foundation Research Program (6.1)

Objective: To better understand the relationship between air-sea interaction and the variability of underwater sound propagating through the upper layers of the ocean.

Summary: This project is an ambitious one preparing to make simultaneous measurements of air-sea exchange, ocean sound velocity microstructure and acoustic variability in the upper layers of the ocean. An experimental setup has been designed for high frequency measurements in shallow water. Preliminary designs have been considered for open ocean measurements. Available equipment has been calibrated and tested, necessary new equipment ordered. Analysis of results obtained in a previous experiment conducted by one of the Investigators (Dr. Denner) off New Zealand has been completed and the results submitted for publication. A correlation between surface heating and mixing and acoustical variability are shown. More carefully controlled experiments such as this effort are clearly justified. This work is essential to understanding the performance of Navy acoustical weapons such as the torpedo and mine.

Publications: W. W. Denner, B. G. Rickard and A. C. Kibblewhite "A temperature Microstructure Probe", Marine Sciences Communications, Vol 3 (1) P 61-91. 1977

W. W. Denner, B. F. Rickard and A. C. Kibblewhite "A Study of Temperature Microstructure in Coastal Waters, submitted to Deep Sea Research.

W. W. Denner, B. F. Richard and A. C. Kibblewhite, "Temperature Microstructure and its Influence Upon the Propagation of Ultrasonic Sound in the Sea", submitted to Deep Sea Research.

Title: Biochemical Modelling of Marine Ecosystems  
And Acoustic Prediction

Investigator: Eugene D. Traganza, Associate Professor of  
Oceanography

Sponsors: Foundation Research Program (6.1),  
Office of Naval Research, and  
Fleet Numerical Weather Central

Objective: To utilize biochemical measurements of  
plankton in models which link them with  
environmental and acoustic properties of  
the ocean.

Summary: Marine Ecosystems include many kinds of  
organisms which affect sound in the sea,  
ranging in size from microscopic plankton  
in the surface layers to midwater fishes  
and ubiquitous whales. Marine organisms  
may either be sources of noise which can  
mask the sounds of submarines or form dis-  
continuities in the physical medium which  
intercept and reradiate or "scatter" acous-  
tic signals, an effect which can confuse  
Naval weapons systems or seriously reduce  
the active detection range of sonar. One  
hypothesis is that zooplankton estimates  
can be useful in predictive models of  
"sound scattering" by virtue of their im-  
portance in marine ecosystems. The eco-  
system is the most suitable level of bio-  
logical organization for application of  
systems analysis techniques and should  
lend itself to acoustic modelling.

A major problem with modelling marine eco-  
systems is that understanding has been se-  
verely limited by the inadequacy in assessing  
zooplankton biomass, production or trophic  
level and the consequent lack of a compre-  
hensive knowledge of regional and seasonal  
relationships with environmental parameters.



The first objectives of this study have been:

- (1) to evaluate the general feasibility of the zooplankton-sound scattering hypothesis.
- (2) to evaluate devices for collecting statistically significant numbers of samples of zooplankton of different sizes.
- (3) to evaluate the potential of making rapid biochemical measurements of zooplankton biomass in samples which may also contain phytoplankton and detritus.
- (4) to compare the seasonal variation of biochemically assayed biomass of size groups with zooplankton biomass predicted by an ecosystem model of the Monterey upwelling region.

Future objectives include (1) addition of biochemical methods which will distinguish which zooplankton are herbivorous and (2) comparison of seasonal/regional sound scattering with modelled and measured variation of phytoplankton, zooplankton and scattering.

A summary of progress so far is as follows:

- (1) A background study produced a "volume reverberation"-zooplankton regression model of the North Atlantic and North Pacific oceans (Traganza and Stewart, 1973; Solomon, 1975; Stewart, 1972) which indicated that regional and seasonal sound scattering can be quantitatively associated with the distribution of zooplankton.
- (2) The background, preliminary results, and the preliminary analytical scheme for relating herbivorous zooplankton to an ecosystem model were reviewed (Traganza and Graham, 1975).
- (3) A carbon method was developed in this study which has proven to be highly successful measure of total biomass of "net zooplankton" and has received a wide international response from other investigators (Traganza, Radney and Graham, 1976; Radney, 1975).

(4) Field and laboratory studies of the adenosine triphosphate (ATP) content of zooplankton indicated that it may be possible to distinguish between living and dead biomass in a sample of zooplankton pending development.

(5) A size sampling in situ net system (SSISNET) was developed and tested in wind tunnel experiments at NPS(Mitchke, 1976).

(6) Initial attempts have been made to simulate seasonal variation of plankton and nutrient levels in the Monterey ecosystem (Pearson, 1975 and Hendrickson, 1976) on the basis of cumulative historical trends of key forcing functions including light, wind, temperature and depth of the mixed layer.

New developments: Fifteen stations were occupied along a transect from Gibraltar to Dakar, Africa to Puerto Rico. A newly constructed SSISNET containing two standard 30 cm nets in series was used to collect 50 Meter samples of the 333 to 1800- $\mu$ m zooplankton in the upper 350 meters of the water column. The ATP content of these samples showed distinct maxima at the same geographic locations which showed distinct dissolved methane maxima. The ATP and methane maximum did not always occur at exactly the same depth, but both were in or near the thermocline. The results suggest that the biological production of dissolved methane may occur in situ in the pelagic ecosystem. A possible mechanism may be the presence of methane bacteria in the digestive tract of herbivorous zooplankton.

Publications:

E. D. Traganza, and K. J. Graham, "Carbon/Adenosine Triphosphate Ratios in Marine Zooplankton", Deep Sea Research, 24 10 pp, 1977.

E. D. Traganza, J. C. Radney, and K. J. Graham, "A Convenient Method For The Determination of Carbon In Marine Net Zooplankton", Marine Chemistry, Vol 7: 110-119, 1976.

Theses Directed: D. E. Henrickson, "An Evaluation Of A Computer Simulation Model Of Plankton Dynamics In Monterey Bay", Master's thesis, September 1976.

R. P. Mitchke, "Design And Wind Tunnel Test Of A Size Sampling In Situ Net System, (SSISNET)", Master's thesis, September 1976.

R. T. Pearson, "A Computer Simulation Model Of Seasonal Variations In Ocean Production For A Region Of Upwelling", Master's thesis, September 1976.

**Title:** Metered Studies Of The California Counter-current

**Investigators:** J. B. Wickham, Associate Professor of Oceanography  
S. P. Tucker, Associate Professor, Oceanography

**Sponsor:** Foundation Research Program (6.1)

**Objective:** The objective for this study was to gather and test equipment to be used in a large-scale direct metering of currents and water mass properties of The California Counter-current. This effort was a part of continuing studies by these investigators of the California Countercurrent. It extends the previous work by use of direct measurements and continuous recording of currents and continuous recording of water mass properties. The ultimate objective is to document the form and variation of the countercurrent on a variety of time scales.

**Summary:** Foundation support has been used in the following activities:

1. Calibration of 4 Aanderaa current meters in towing tank at Scripps Institution of Oceanography.
2. Visit to Oregon State University laboratory for demonstrations and discussion about deployment, recovery and maintenance of moored buoys and current meters.
3. Bench testing of acoustic and timed releases to be used in metering project.
4. Field testing of seven acoustic releases in water depths between zoo and zoom.
5. Research into sources of supply and characteristics of equipment to be ordered for metering program and into procedures for mooring operations.
6. Studies of recent theoretical models of eastern boundary currents, these to serve as the basis for appropriate design of out sensing array (or antenna).

**Publications:** None



Title: Studies in Applied Mechanics

Investigator: J. E. Brock, Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.1)

Objective: To develop and submit for publication several studies in the field of Applied Mechanics.

Summary: Several such studies were brought to completion, papers written up and submitted, and of these most have been accepted for publication. Other studies continue. Nine separate investigations are briefly described in the following numbered paragraphs.

(1) This study reports on the very close agreement between theory and experiment for behavior of a uniform cantilever beam excited in flexural vibrations by the sudden release of a lateral load at the tip. An experimentally generated trace of flexural stress vs. time at a point on the beam appears so spiky and grassy that analytical agreement appears unlikely. However, a computer generated graph, employing the complete eigensolution using the Bernoulli-Euler-Navier model of a beam, agrees in fine detail with the experimentally determined graph.

(2) The oblateness of the earth can be represented to a very high degree of accuracy by a simple model consisting of one positive and two negative mass particles located on the polar axis. At points exterior to the earth's surface, the geopotential exerted by this model is almost exactly the same as that exerted by the actual earth. This permits constructing very simple computer programs for the behavior of earth satellites, and, in particular, facilitates a demonstration of the phenomena of advance of perigee point and motion of the line of nodes.

(3) Snap-through behavior of structural elements is important in technology. For example, ship's plating behaves in this fashion, this behavior being called "panting." The phenomenon is difficult to treat analytically. This study treats a particularly simple case so that the student has ready access to a

complete illustrative example.

(4) A simple experiment is described which illustrates plastic bending and permits confirmation of the theoretical moment-curvature relation for a rectangular cross section.

(5) Although elastic buckling of a single strut-like element, with specified end conditions is well understood and relatively easily presented to students, the buckling behavior of structures is not at all well understood and is frequently mishandled in textbooks and in the general literature. Professor R. E. Newton and the writer have previously written on this subject. The present study traces the evolution of a simple structure as a spring-like element is modified so as to introduce a non-linear behavior and shows that quite unexpected phenomena are associated with the modified structure. The analysis is surprisingly difficult.

(6) In a recent publication in the Journal of Applied Mechanics the authors treated a very special problem involving estimating the gravest vibration frequency of a torsional system. The present study shows that the Dunkerley-Mikhlin estimates are immediately at hand for a significant generalization of the problem. It also provides an alternate treatment, using the Hamilton-Cayley theorem and Chebychev polynomials, for the special case treated by the earlier authors.

(7) The literature does not seem to afford a simple example of a complete solution for the Euler buckling of a practically realizable nonuniform strut. This study supplies such an example. The eigenfunctions are modified Gegenbauer polynomials.

(8) Several studies are still under way on the general subject of plastic behavior of structural plates. A general theorem has been formulated which permits obtaining upper bounds without the necessity of specifying or constructing a moment field. This theorem has yielded many of the classical results and has been used to treat the problem of an elliptical

plate with a concentrated load in a general position near the center of the plate. The theorem seems to lend itself to use with a computer optimizing program such as COPES which is implemented at the NPS computer center and it is anticipated that some analyses will be made using this facility.

(9) The writer presented the Dunkerley-Mikhlin formulas in a paper to the Journal of Applied Mechanics. The present paper provides a more elegant derivation based on the idempotency of the filtering matrix. Another physical example is presented illustrating the power of the method.

Publications: John E. Brock, "An experiment on the Vibration of Cantilevers," accepted for publication by IJMEE (International Journal of Mechanical Engineering Education).

John E. Brock, "A Simple Model of Oblate Earth," Accepted for Publication by IJMEE.

John E. Brock, "Simple Snap-through Behavior of a prismatic Bar," Accepted for publication by IJMEE.

John E. Brock, "Buckling of Simple Elastic Structures -- a Complicated and Deceptive Subject," Accepted for publication by IJMEE.

John E. Brock, "Lower Bounds for Gravest Torsional Frequencies," Accepted for publication by the Journal of Applied Mechanics.

John E. Brock, "An Euler Buckling Eigensystem for a Nonprismatic Strut," Submitted to the Journal of Applied Mechanics.

John E. Brock, "An Improved Derivation of the Dunkerley-Mikhlin Formula, "The Shock and Vibration Bulletin, No. 47, Part 2, (September 1977), pp. 17-18.

John E. Brock, "A Simple Laboratory Experiment in Plastic Bending," Accepted for publication by IJMEE.

Title: Holographic Nondestructive Test NDT

Investigator: A. E. Fuhs, Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.1)

Objective: To determine the suitability of holographic nondestructive test as a means of locating weld flaws in piping.

Summary: Real time holography is used to obtain fringe patterns. Fringe patterns are interpreted in terms of surface displacement. Flaws in piping welds have anomalous surface displacements. To check sensitivity a finite element computer code is used to predict surface displacement. Pipes with manufactured cracks are test specimens.

The holography system has been assembled. Holograms have been made. Test specimens have been assembled including the following: stainless steel piping with manufactured cracks for correlation with finite element computer code, reject piping from Mare Island shipyard, and aircraft components with known fatigue cracks obtained from NARF Alameda. The finite element computer code is 85 per cent complete.

Publications: A. E. Fuhs, B. W. Hannah and W. L. King, Jr., "Technical Comment on 'Extensions of Dual-Plate Holography Interferometry'," AIAA Journal, pp. 725-727, 1977. (Accepted for publication in AIAA Journal, February 1978)



Title: Shaped Charges For Neutralization of Buried Mines

Investigator: A. E. Fuhs, Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.2)

Objective: To develop a technique to neutralize buried mines. The technique is to be used by EOD officers and crew.

Summary: Mines may be buried at depths from a few inches to 6-8 feet. The buried mines are detected and located by magnetic means. Error in location may be comparable to buried depth. Some means of placing an explosive charge near the mine is required. A shaped charge can open a large hole through which a charge can be rammed.

An assembly of charges was designed, built, and tested. The assembly of charges consisted of a 2-inch diameter shaped charge with  $\frac{1}{2}$  lb HE located on top of a cylinder containing liquid explosive. The cylinder had a coaxial tube which allowed passage of the metal jet from the shaped charge. It was found that the liquid explosive spray lined the hole; it was also found that the cylinder for the liquid explosive was rammed down the hole. As a result of these early tests, a series of tests is being planned using solid explosive located below the shaped charge. A time delay detonator will be used for the solid explosive.

Publication: None

Title: Melting of Ice Subjected to Turbulent Flow of Sea Water

Investigators: A. E. Fuhs, Professor of Mechanical Engineering  
R. Stolfi, Associate Professor of National Security Affairs  
W. W. Denner, Associate Professor of Oceanography  
R. Bourke, Associate Professor of Oceanography  
P. Wang, Associate Professor of Mathematics  
LT W. Clifford, USN, Graduate Student in Naval Engineering  
LT R. Erman, USN, Graduate Student in Naval Engineering  
Dr. O. Griffin, Naval Research Laboratory

Sponsor: Foundation Research Program (6.1)

Objective: To determine the rate of regression of fresh-water ice subjected to turbulent flow of sea water. Further, to develop an analytical model which allows prediction of the ice melting rate and heat transfer rates.

Summary: Large blocks of ice with dimensions 16 x 4 x 2 feet are frozen. The ice blocks are instrumented with thermocouples to measure gradients in the thermal boundary layer and in the ice. The blocks are towed at speeds of 0.7 to 1.2 knots. Weights are obtained before and after towing. Measurements are made of the dimensions of the ice block before and after towing.

As of November 28, 1977, three blocks of ice have been towed in Monterey Bay. Nusselt numbers for heat transfer have been obtained. The regression rate has been correlated using the computer code of Dr. Owen Griffin. Ice ripples have been observed and measured. The observations of ice ripples correlate well with existing theories. Temperatures in the base flow region have been determined. A thermal boundary layer profile has been obtained.

Conference

Presentations: Allen E. Fuhs, Warren W. Denner, Matthew Kelleher, William Clifford, Reginald Erman, Russel Stolfi, Robert H. Bourke, and Peter C. C. Wang, "Self Propelled Iceberg." Paper presented by Allen E. Fuhs at the First International Conference on Iceberg Utilization for Fresh Water Production, Weather Modification and Other Applications, Ames, Iowa, October 2-6, 1977. Paper to be published in Proceedings.

Russel Stolfi, Allen Fuhs, Peter Wang, Robert Bourke and Lieutenants Reginald Erman, William Clifford, USN, "Ice Moving in Sea Water." Paper presented by R. Stolfi at the First International Conference on Iceberg Utilization for Fresh Water Production, Weather Modification and Other Applications, Ames, Iowa, October 2-6, 1977. Paper to be published in Proceedings.

Title: Warm Working of Eutectic and Eutectoid alloys to produce Fine Microstructures

Investigator: T. R. McNelley, Assistant Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.2)

Objective: Production of fine, spherodized microstructures in Al-Cu and Al-Mg alloys by warm working and evaluation of subsequent mechanical properties, especially ambient temperature properties.

Summary: The objectives of this research were met. Fine two-phase microstructures were produced in both an Al-Cu alloy and several Al-Mg alloys. Subsequent mechanical characterization of these alloys has revealed that excellent mechanical properties can be developed in Aluminum-Magnesium alloys containing 11% to 14% magnesium by weight. Flow-stress values up to 90,000 psi were obtained, for example, in one alloy. This has lead to a focusing of this research primarily on the Al-Mg system; some additional practical factors concerning this system are that these alloys are less dense than conventional aluminum alloys, and the alloys being studied also exhibit superplasticity at warm temperatures. Research will now focus on the processing and related mechanical properties of these Al-Mg alloys.

Publications: None.

Theses  
Directed: A. L. Cipriani, "An Investigation of the Mechanical Properties of Warm-Rolled Aluminum-17.5 weight percent Copper alloy," Master's Thesis, December 1976

F. G. Ness, "High Strength to Weight Aluminum-18 Weight percent Magnesium alloy through Thermomechanical Processing," Master's Thesis, December 1976

T. L. Glover, "Effects of Thermo Mechanical Processing on Aluminum-Magnesium, Alloys Containing High Weight Percentage Magnesium" Master's Thesis, December 1977



C. P. Bingay, "Microstructural Response of  
Aluminum-Magnesium Alloys to Thermomechanical  
Processing," Masters Thesis, December 1977

Title: Microgalvanic Aspects of Seawater Corrosion (MASC)

Investigators: J. Perkins, Associate Professor of Materials Science  
K. J. Graham, Chemist, Physics and Chemistry Department

Sponsor: Foundation Research Program (6.1)

Objective: To determine environmental effects on seawater corrosion of structural materials of Navy interest, with an emphasis on the correlation of electrochemical factors with corrosion rates and with corrosion product distribution, micromorphology and base metal microstructural features.

Summary: Of constant concern to the Navy is the problem of seawater corrosion of ships' structural materials. Also, fouling of seawater piping systems by marine organisms is a serious problem. Unfortunately, the solutions to these two coincidental problems are not always compatible. For example, one method of control of biological fouling involves the addition of growth inhibitors such as hypochlorite ion to the seawater prior to entry into the piping system. Moderate levels of hypochlorite ion are known to effectively control biological growth. However, increases in hypochlorite ion concentration also typically lead to increases in corrosion rate. Also, the units which electrochemically produce the ionic growth inhibitor tend to develop very high concentrations of hypochlorite near the generator, which is not diluted until downstream in the condensers.

This problem is currently being studied through a combination of electrochemical techniques, corrosion rate determinations, and direct microscopic observation techniques. The effects of varying concentrations of inhibitor ion and of other seawater constituents on the corrosion rates of various piping materials and marine fastener materials is being considered. Specimens are being evaluated potentiostatically in known environments, with the data from these

experiments being correlated with microscopic observables using scanning electron microscopy and microbeam energy dispersive X-ray spectroscopy.

Work accomplished during this time period has included experiments involving aluminum structural alloys, MILSPEC zinc and developmental aluminum sacrificial anodes, and several copperbased alloys. Current work in concentrating on cupronickel alloys and brasses.

Publications:

J. Perkins, W. H. Leubke, K. J. Graham and J. M. Todd, "Anodic Corrosion of Zinc Alloys in Seawater", Journal of the Electrochemical Society, 124, (1977), 819-826.

J. Perkins, K. J. Graham, G. A. Storm, J. S. Locke and J. R. Cummings, "Effect of Velocity on Corrosion of Galvanic Couples in Seawater", NACE Unit Committee T-7C "Symposium on Marine Corrosion", to be presented at CORROSION/78, NACE, Houston, Texas, March 6-10, 1978.

J. Perkins, J. S. Locke, and K. J. Graham, "Effects of Dissimilar Metal Coupling, Potential Distribution, and Temper condition on Galvanic Corrosion of 5086 Aluminum Alloy in Synthetic Seawater", NPS Technical Report, NPS-69Ps-78-001, January 1978.

# APPENDIX I

<u>Summary Title</u>	<u>Investigator</u>	<u>Type Funding</u>
MATHEMATICS		
Computational Basis Functions For Optimal Approximations	R. Franke	6.1
Convergence of the Method of Parallel Displacements For Unconstrained Minimization in the Non-Quadratic Case	I. B. Russak	6.1
Necessary Conditions For Problems Involving Higher Derivative Bounded State Variables	I. B. Russak	6.1
Analysis of Methods For Estimating Reliability Bounds	A. L. Schoenstadt	6.1
The Calculation of $e^{At}$ With Some Applications	L. Stewart	6.1
ADMINISTRATIVE SCIENCES		
Derivations of Critical Planning Properties of the Process Associated With Generating Demands For Health Care	D. Whipple	6.2
OPERATIONS RESEARCH		
Investigation of a Sequential Median Test	D. R. Barr	6.2
Analysis of a Class of Binary Trees Arising From Certain Applications in Sorting and Information Retrieval	G. G. Brown B. O. Shubert	6.1
Lanchester-Type Models of Warfare (Monograph)	J. G. Taylor	6.1
Convexity in an Inventory Model	P. W. Zehna	6.2



<u>Summary Title</u>	<u>Investigator</u>	<u>Type Funding</u>
NATIONAL SECURITY AFFAIRS		
Canadian Armed Forces Unification: The Effects After Ten Years	D. P. Burke	6.1
The Use of Expert Opinion in Congressional Roll Call Analysis	E. J. Laurance	6.1
The CENTO Alliance: Status and Prospects	R. H. Magnus	6.1
The USSR, Eastern Europe and Erocommunism	J. Valenta	6.1
The Soviet Intervention In Czechoslovakia, 1968	J. Valenta	6.1
The Soviet Intervention In Angola	J. Valenta	6.1
PHYSICS AND CHEMISTRY		
Investigation of Nuclei Giant Multipole Resonances by Inelastic Electron Scattering	F. R. Buskirk J. N. Dyer R. Pitthan	6.1
Laser Produced Plasmas	A. W. Cooper F. Schwirzke	6.1
Computer Simulation of Sputtering by Molecules	D. E. Harrison, Jr.	6.1
Magnetic Noise in and Near the Ocean	O. Heinz	6.1
Spectroscopic Data Center: Compilation of Short Ultraviolet (XUV) Spectra	R. L. Kelly	6.1
Elastic Waves in Crystals	J. R. Neighbours	6.1
Homogeneous Catalysis by Palladium Complexes	R. A. Reinhardt	6.1

<u>Summary Title</u>	<u>Investigator</u>	<u>Type Funding</u>
PHYSICS AND CHEMISTRY, cont.		
Frequency Response of Cold Wires Used For Atmospheric Turbulence Measurements in the Marine Environment	G. A. Schacher G. W. Fairall	6.1
ELECTRICAL ENGINEERING		
Interval Modulation of a Sinusoidal Carrier	G. Myers	6.2
Researches in Digital Filters	S. R. Parker	6.1
Computer Aided Acoustical Imaging	J. P. Powers	6.2
Sampled Analog Signal Processing	T. F. Tao	6.2
AERONAUTICS		
Aerodynamic Stabilization of Gaseous Discharges	O. Biblarz	6.2
OCEANOGRAPHY		
Acoustic Variability and Air-Sea Exchange	W. W. Denner K. L. Davidson T. M. Houlihan J. V. Sanders E. B. Thornton	6.1
Biochemical Modelling of Marine Ecosystems and Acoustic Prediction	E. D. Traganza	6.1
Metered Studies of The California Countercurrent	J. B. Wickham S. P. Tucker	6.1
MECHANICAL ENGINEERING		
Studies in Applied Mechanics	J. E. Brock	6.1
Holographic Nondestructive Test NDT	A. E. Fuhs	6.1

<u>Summary Title</u>	<u>Investigator</u>	<u>Type Funding</u>
MECHANICAL ENGINEERING		
Shaped Charges For Neutralization of Buried Mines	A. E. Fuhs	6.2
Melting of Ice Subjected to Turbulent Flow of Sea Water	A. E. Fuhs R. Stolfi W. W. Denner R. Bourke P. Wang LT R. Erman O. Griffin	6.1
Warm Working of Eutectic and Etectoid Alloys to Produce Fine Miscrostructures	T. R. McNelley	6.2
Microgalvanic Aspects of Seawater Corrosion (MASC)	J. Perkins K. J. Graham	6.1

#### PROGRAM REVIEW

The Foundation Research Program is monitored by the Pasadena Branch Office of the Office of Naval Research.



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